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ABSTRACT

Transfer of learning in the acquisition of motor skills, centered around proactive and retroactive experimental designs, is discussed. The structures of the two designs are explained and compared. The effect upon transfer of learning by both stimulus and response gradients is examined. Phenomena contributing to negative transfer are investigated, and contributing factors to this retroaction are identified. It is observed that almost all transfer of learning involves both positive and negative elements and that the element determining the nature of transfer is often attributable to the environmental consequences of the activity. (MJB)

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TRANSFER OF LEARNING IN THE ACQUISITION OF MOTOR SKILLS

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The phenomenon of transfer constitutes one of the oldest and most widely studied areas within motor learning. Research upon transfer of learning has centered around the use of two basic experimental designs, the proactive and the retroactive paradigms. The design for proaction involves the effects of a previously acquired task upon the acquisition of a succeeding skill. The simplest form of the proactive design involves an experimental group that receives instruction on an initial task (the independent variable) and a control group that receives no such instruction. The performance of both groups is then compared on some criterion measure or transfer task (the dependent variable). If the experimental group demonstrates performance that is significantly superior to that of the control group, a positive transfer exists between the initial task and the criterion task. This positive transfer is referred to as proactive facilitation. If, in contrast, the experimental group is significantly inferior to the control group upon the criterion task, then negative transfer or proactive inhibition has occurred.

The basic paradigm for retroaction involves the initial acquisition of the criterion task by both the experimental group and the control group. The experimental group is then taught a second task (the independent variable) while the control group remains inactive. Both groups are then retested on the initial skill (the dependent variable). If the experimental group's performance is significantly superior to that of the control group, retroactive facilitation is said to have occurred. But should the experimental group's performance be significantly poorer than that of

the control group, retroactive inhibition results.

Although a number of theoretical explanations have been offered to account for the phenomena of retroaction and proaction, none provides an entirely satisfactory explanation. Theoretical controversies concerning the nature of negative transfer have characteristically centered about two fundamental issues, the role of retention and that of interference. Proponents of a retention hypothesis contend that negative transfer results from the weakening or decay of the initial response over time alone (forgetting). Advocates of an interference hypothesis contend that the acquisition of a second response results in competition with the original one for the available storage capacity (memory). Since the demands of the situation outweigh the capacity of the learner, there is a resultant decrement in performance.

Although it is the effects of <u>proactive</u> inhibition which have a great bearing upon practical learning situations in terms of the degree to which prior experience will effect current learning, the bulk of theoretical research upon transfer has, until fairly recently, been overwhelmingly concerned with <u>retroaction</u>, particularly as it occurs under highly controlled laboratory conditions. Current theoretical explanations of proaction are therefore primarily rooted in prior findings concerned with retroaction. It is generally conceded that proaction results from the effects of competition (interference) only, while retroaction is believed to occur as a result of both competition and time.

Further support for the interference hypothesis is provided by

Hicks and Cohn (1975), who write that the amount of retroactive inhibition has been found to be an increasing function of the amount of interpolated learning in the case of both verbal and motor tasks. In contrast to the predictions of the two factor theory of retroactive inhibition, no change in the effects of interpolated learning was observed as the length of the retention interval was increased. The authors also failed to observe any evidence of proactive inhibition and conclude therefore that in terms of the particular motor tasks employed in this investigation (the Tsai-Partington numbers test), retroaction and proaction do not appear to be the result of a common interference mechanism. Based upon the lack of observed interaction between the number of interpolated learning trials and the length of the retention interval, Hicks and Cohn contend that the interference processes operating in the case of motor skill acquisition differ from those which effect verbal learning.

Dickinson and Higgins (1977), in contrast, observed both proactive and retroactive interference effects in the case of a linear arm-positioning task. These interference effects diminished however as the movement characteristics (length of movement in this case) of the criterion response were altered. The authors contend that these findings lend support to the contention that the acquisition and retention of both verbal and motor skills are prone to interference from either prior or interpolated activities with characteristics similar to the criterion response.

Gagné et al. (1950) write that the critical element in determining transfer of learning pertains to the degree of intratask similarity

governing the relationships among the stimulus and response elements within a given task. The authors contend that this similarity may be varied in four ways: by making the stimulus elements within the second task more like those within the first task; by making the stimulus elements within the second task less like those of the first; by altering each of the stimuli in the second task along a scale of similarity with those of the first; and by reversing the relationships between the stimuli and responses in the second task. The first three variations tend to result in positive transfer, while the fourth results in negative transfer.

These transfer effects are believed to result from a generalization gradient which effects both stimulus and response elements. Gagné contends that these gradients, which themselves are mediated by cognitive processes, exert their greatest effects upon transfer during the initial phases of skill acquisition but diminish in importance as proficiency is attained and the required discriminations become more firmly established. The concept of the stimulus generalization gradient is based upon the assumption that the acquisition of a given response to a particular stimulus situation will increase the chances of making the same response when one is confronted with a stimulus similar to the original one. (An individual taught to stop at a red light will readily transfer this response to a situation wherein he is presented with an orange light.)

The authors contend that the processes which underlie transfer of learning are also dependent upon a response generalization gradient. This position is based upon the assumption that an individual who learns a specific response to a given stimulus also acquires the tendency to

make different responses to the same stimulus. A person taught to perform a task in a specific fashion often develops alternative styles of executing the same task; someone who has learned to serve a tennis ball in a particular manner may vary his performance to attain greater comfort or efficiency. These tendencies to generalize a response decrease however as the similarity between the initial response and the transfer task decrease. Gagné et al. write that although a motor response is believed to vary in terms of such aspects as its direction, distance, force and rate, the degree of similarity between any two motor responses is assessed in terms of the actual results of the movement rather than in terms of the patterns of muscular activity employed in the execution of the response. Two movements are viewed as similar when they both serve to fulfill a similar environmental goal (an overhand throw and a side arm throw, for example). An individual who is taught to throw overhand may also tend to accomplish the stated environmental goal by throwing side arm.

Dey (1977) writes that the relationship between similarity and negative transfer rests largely upon the concept of the stimulus-response generalization gradient. Two hypotheses based upon this concept have been formulated, but so far they have been applied mainly to verbal learning. The first of these is the hypothesis of parasitic reinforcement, which states that reinforced practice during the acquisition of the initial task strengthens not only that particular response but serves to strengthen similar responses as well, and thereby increases the chance of negative transfer resulting. The second hypothesis is based upon the

concept of a mediational chain which enables an entire response pattern to occur in a programed sequence. The greater the degree of similarity between the correct elements in the sequence and other extraneous responses which are readily avialable (stepping sideward instead of forward during the delivery in bowling, for example), the greater the chance of obtaining negative transfer. In both hypotheses, the greater the similarity between the stimulus situations of both the initial and transfer tasks (similarities in the type of equipment employed, method of instruction or surrounding conditions) and the greater the similarity between the response requirements of the initial task and the transfer task (stepping forward with the right leg in the first task, as opposed to stepping forward with the left leg in the second), the greater the resultant stimulus-response generalization gradient and the greater the likelihood of negative transfer resulting between the tasks.

Dey (1977) observed significant interaction effects among stimulus similarity, response similarity, and negative transfer in the acquisition of a motor task (card sorting). These interactions were attributed to the tendency of a given motor response to deviate from its correct course because of conflict with other responses. The author contends that a given stimulus invokes not only its own response but serves also to elicit responses which have been previously conditioned to similar stimuli. A gymnastics student who learns the hand spring following the prior acquisition of the neck spring may often confuse the two responses, and the execution of the hand spring will result in the presence of responses (such as bending the elbows) appropriate to the neck

spring. The conflict between these two simultaneously evoked, incompatible responses results in the emergence of a conflict resultant or hybrid response (in the form of neither a hand spring nor a neck spring) which lies somewhere between the two conflicting responses. Dey contends that the amount of negative transfer and interference are directly proportional to the distance (as measured along a continuum of similarity) between the correct response and the hybrid one. The distance (degree of similarity) between these two responses (correct and hybrid) is believed to increase in proportion to the distance between the correct response (the hand spring in this case) and the erroneous one (the neck spring).

A verbal example of a conflict resultant can be found in the case of the language student whose prior knowledge of Spanish interferes with his learning of French. He learns the correct response, the French word for window (la fenêtre), confuses it with an incorrect response, the Spanish word for window (la ventana), and comes up with a hybrid response, the nonsense word "la fentana". The greater the similarity (distance) between the French word and the Spanish one, the greater the likelihood of confusing the two and, even more important, the more difficult it becomes to distinguish between the hybrid response and the correct one.

In summary, Dey contends that an inverse relationship should exist between interference and response similarity. (The more two motor responses are alike, the greater the negative transfer and conversely, the less the similarity, the less the negative transfer.) The author argues that the greater the similarity between the correct response and the conflict resultant, the greater the strength of the hybrid response in

relation to that of the correct response and the greater the resultant interference. Developing a "bad habit" in the performance of a motor skill constitutes a common example of the effects of such interference. The greater the similarity in the prevailing stimulus conditions (a tennis court and a badminton court, for example), the greater the likelihood of eliciting an incorrect response (a tennis swing while playing badminton or a badminton strike when playing tennis). The greater the similarity between the two responses (the tennis stroke and the badminton stroke in this case), the more difficult it is to distinguish between the hybrid response (either a tennis stroke which partially resembles a badminton stroke or a badminton stroke which resembles a tennis stroke) and the correct response (either the proper tennis swing or the proper badminton swing). And the greater the resemblance between the correct response and the hybrid response, the more subtle the decrement in performance and the greater the difficulty in detecting it and effecting the appropriate corrections. Gross mistakes are far easier to detect and correct than are subtle errors.

Holding (1976) argues that positive and negative transfer constitute relative rather than absolute values since, to a varying degree, both of these elements are present in every transfer of learning situation. He contends that the perceived consequences of transfer (either positive or negative) are due often to methodological or procedural factors (the use of a particular scoring system, for example) rather than resulting from factors inherent in either the initial or the criterion learning task. Negative transfer is viewed as a situation in

which positive transfer is misplaced. According to Holding, a subject trained to behave in a certain way will, under similar circumstances, continue to do so. When maintenance of the initial behavior is viewed as correct by the teacher or experimenter, positive transfer results. But if the initial behavior is termed incorrect, negative transfer ensues. In essence, negative transfer results when the criterion has been changed but the subject's behavior has not.

There are a number of factors which contribute to such negative transfer. When the subject has not yet attained a high level of proficiency upon the initial task, there is a greater tendency toward response generalization and a resultant failure to discriminate between the precise response requirements of the transfer task and those of the initial task. Simply stated, the less skilled an individual, the greater the likelihood of negative transfer when confronted with a similar yet different response situation. For example, the would-be "do-it-yourselfer" with limited experience in the wiring of a doorbell causes extensive damage when he attempts to effect repairs upon a complex electrical circuit in the main wiring of the house. Negative transfer may also result from a lack of information concerning the basis for discriminating between two tasks. Even though situations are different, the learner may not have sufficient information to know how they differ. When the learning task itself does not provide sufficient information to allow the subject to discriminate, such information must be provided in the form of advanced instruction concerning the specific properties of the learning tasks. Unfortunately, the failure to remember such instructions often results in negative transfer.

The subject's ability to accurately differentiate between the requirements of the initial task and those of the criterion task constitute a major factor in determining the nature of learning transfer. The failure to make this discrimination results in negative transfer and is a consequence of the operation of one of two fundamentally opposing factors. The first pertains to the high degree of cognitive involvement during the initial stages of skill acquisition and the accompanying broad patterns of response generalization. An individual who has attained a minimal degree of skill at serving a tennis ball, for example, is more than likely to apply the same response pattern when confronted with the task of executing a badminton serve. Although there is a great deal of conceptual similarity between these two responses, they differ considerably in terms of such specific factors as the speed and force of the movement and the mass of the striking implement. Therefore, generalizing the principles which govern the performance of the initial task to the execution of the transfer task is an incorrect response and results in negative transfer. The degree of overlearning of the initial task is the second factor determining the direction of transfer. The better learned a task, the more automatic its execution and hence the greater the likelihood of the subject's reproducing that response even when the prevailing circumstances have been altered.

It would appear from the preceding discussion that, regardless of the extent of prior experience, negative transfer must always result when a second task which is similar to the first is acquired. As previously stated however, almost all transfer of learning involves both positive and negative elements. Often the ultimate factor which serves to deter-

mine the nature of transfer in a given situation rests with the environmental consequences of the activity. Assume that an individual who has initially learned to drive an automobile with an automatic transmission is later taught to drive a standard transmission vehicle. The progress of this individual is compared to that of a second subject with no prior driving experience who is taught initially to drive a standard transmission vehicle. If the person with the prior knowledge of driving experiences only minor difficulties (such as the car's bucking and stalling) and is able to apply the previously acquired driving skill to the new situation, while the new driver has difficulty mastering all of the skills, it can be said that a positive transfer exists between the two tasks. If, however, after a suitable training period, both drivers are faced with an unexpected situation and the one with the prior experience commits an error resulting in a loss of control of the vehicle (improper synchronization of the clutch with the accelerator, for example), then the logical conclusion is that negative transfer has resulted. Frequently it is the outcome of the behavior that determines whether transfer is positive or negative.

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